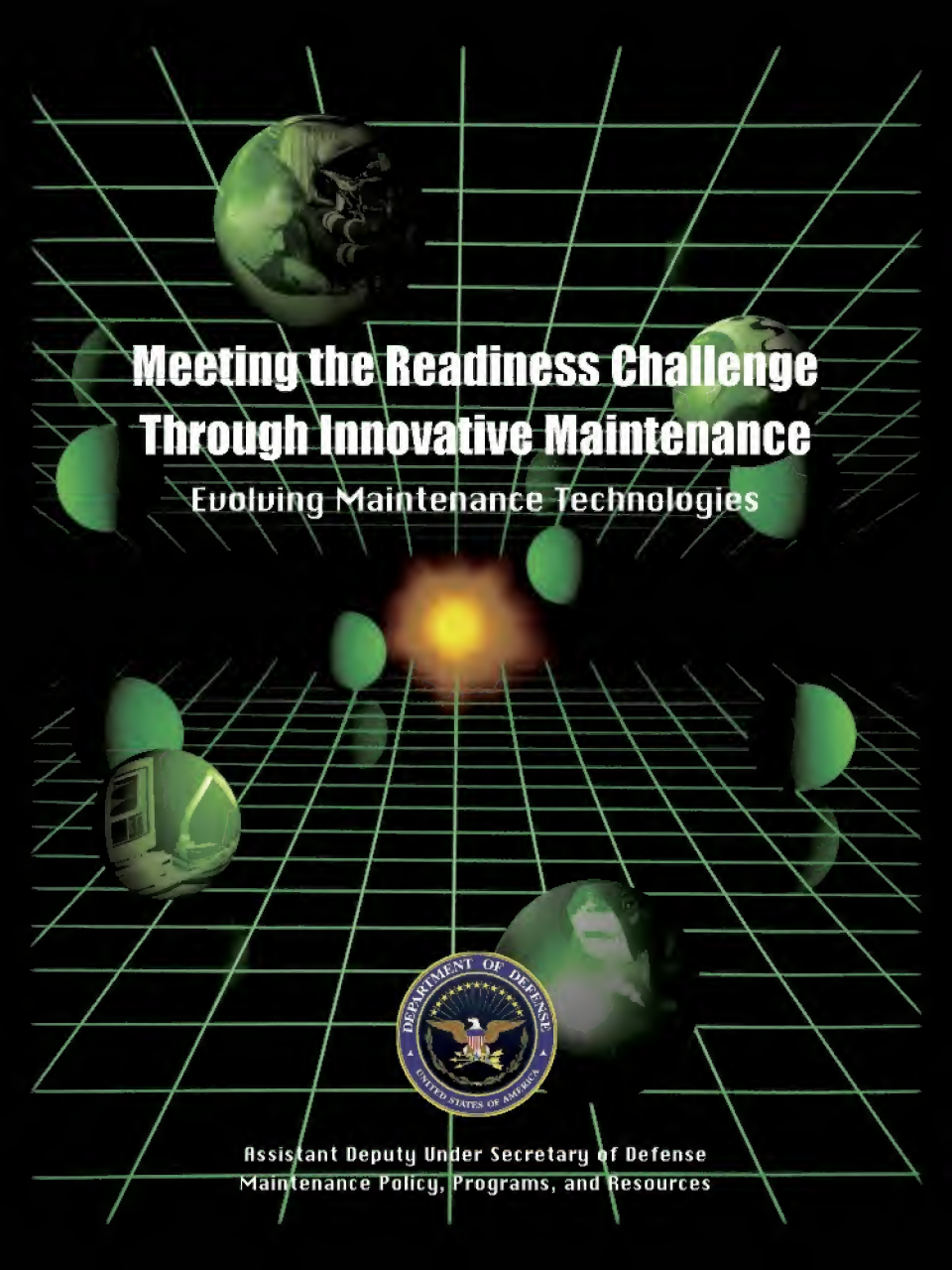


Meeting the Readiness Challenge Through Innovative Maintenance

Evolving Maintenance Technologies

Assistant Deputy Under Secretary of Defense
Maintenance Policy, Programs, and Resources

Improving Maintenance Operations
Three Primary Areas

Processes

Processes can be conceptual, such as

- condition-based maintenance and
- diagnostics and prognostics.

Processes also are specific applications, such as

- laser technology and
- controlled-humidity preservation.

Information Technology

Improvements are being made in maintenance management, such as

- enhanced maintenance information,
- increased production management effectiveness, and
- higher visibility of the cost of ownership,

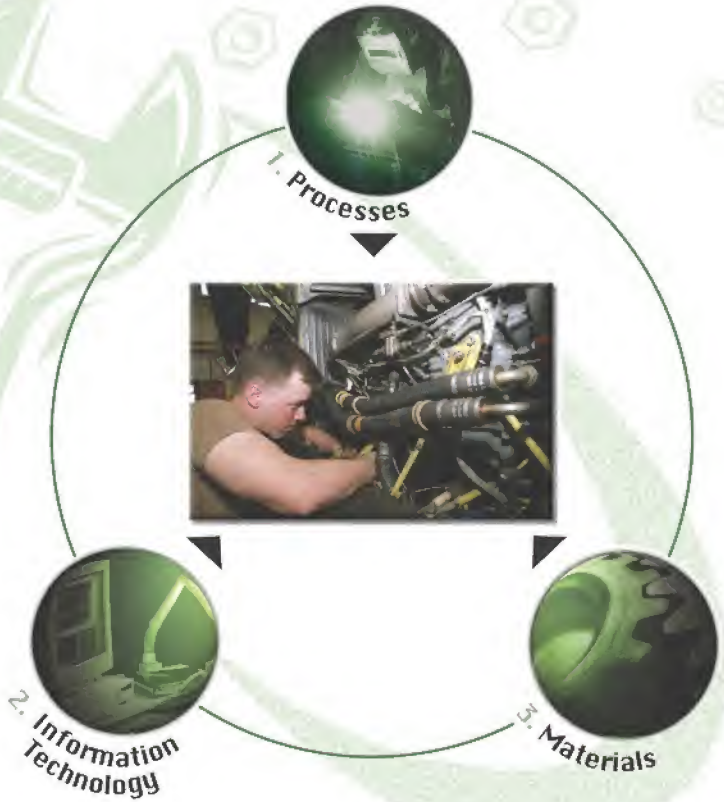
as well as management and support of the repair itself, including

- better electronic technical documentation and
- increased portability in maintenance aids.

Materials

Examples of on-going improvements include

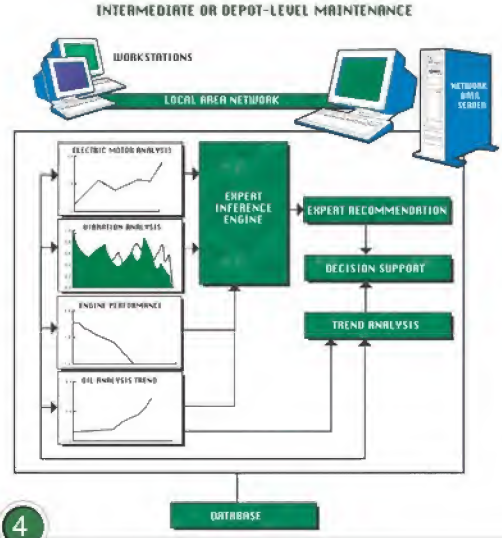
- more durable surface coatings,
- more environmentally friendly solvents,
- easier-to-maintain and low-observable materials,
- easier-to-repair composites, and
- easier-to-replicate embedded microchips.


1. Processes
2. Information Technology
3. Materials

• Condition-Based Maintenance

Condition-based maintenance (CBM) is a form of predictive maintenance based on a real-time or near-real-time assessment of equipment condition obtained from embedded sensors or external tests and measurements using portable devices. The intent of CBM is to perform maintenance only when there is objective evidence of need, rather than doing reactive (run to fail) maintenance or preventative (scheduled) maintenance.

Using CBM can decrease false alarms and prevent unnecessary maintenance. CBM could improve operational readiness and mission reliability.



• Diagnostics and Prognostics

Diagnostics is the practice of using either on-board sensors or off-line measuring devices to detect and isolate faults. It is reactive in nature, but advanced versions will have self-correcting features.

Prognostics is the practice of using current diagnostic capability to predict future failures. Advances in computing power and data storage are making it easier to compile maintenance and performance data about large numbers of similar systems. This capability, coupled with information about stress and load factors for a specific system, are extremely helpful in predicting the remaining useful life of the system.

Examples of Other Process Improvements

• Laser Engineered Net Shape Forming

Laser Engineered Net Shape Forming (LENS) uses a high-powered laser focused on a part or substrate injected with metallic powder until the repair is complete. This new process improves readiness and lowers costs because some parts of aging systems, such as turbine blades, stator assemblies, vanes, and impellers, can be difficult to repair because of heat buildup. LENS offers a significant advantage of lower heat-induced stress and distortion because a much smaller zone is affected by the heat.

• Catalytic Extraction

A molten-metal bath is used to convert wastes to useful materials, such as commodity gases, ceramics, and metals. These then can be recycled, sold, or disposed of. The main benefits are a reduction of hazardous waste and waste disposal fees.

• Laser Cladding

Laser energy is delivered down a fiber-optic tube for depositing material onto a surface. This "cladding" enables repairing of expensive aluminum parts that otherwise would be unrepairable. One example is the 7000 series aluminum alloy used in torpedo components.

• Leak-Test Technology

A new technology being used is a noncontact process using sound to detect leaks. Advantages of this system are that leaks can be detected that are 10 times smaller than those found using current methods; the automated test procedure reduces man-hours and the possibility of human error; fewer pieces of support equipment are necessary; and the mixture is much safer than using pure nitrogen, particularly in enclosed areas, such as fuel tanks.

• Near-Dry Machining of Aluminum

Aluminum is machined without using coolant. The benefits include a potential 15 percent reduction in machining costs, the elimination of the cost and complexity of disposing of coolant, and unquantifiable but significant improvements in environmental and health factors.

• Corrosion Prevention Using Controlled-Humidity Preservation

Controlled-humidity preservation (CHP) as a maintenance technology has the potential for reducing the effects of moisture on DoD's weapons systems. CHP is being selectively integrated into maintenance programs to reduce ownership costs and increase reliability. For example, a substantial number of the Army National Guard's operational combat vehicles are placed in remotely monitored CHP when not being used. This has improved the availability of combat vehicles, reduced maintenance requirements, and improved readiness.

2 Maintenance Technology Advancements

Information Technology

• Automatic Identification Technology

Product information is the backbone of automatic identification technology (AIT). Products could include virtually any item that maintainers touch, from an end item (e.g., a helicopter) to its consumable units (e.g., transmission gears). Each product will be uniquely identified with at least the three data elements listed below:

- Original equipment manufacturer (OEM) identification code
- OEM part or reference number
- OEM tracing number (serial/lot/batch/production number).

Bar Code Reading

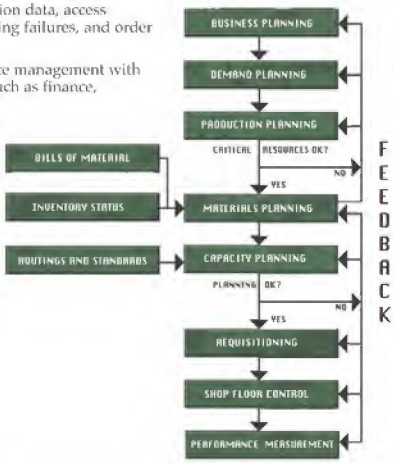
(This is just one example of how the product could be identified and read.)

Maintainers envision AIT will

- improve problem diagnosis, reliability, and trend analysis;
- improve efficiency by reducing time needed to record accurate and comprehensive production data, access technical information, research recurring failures, and order needed parts; and
- enhance the integration of maintenance management with logistics and other functional areas, such as finance, procurement, and e-commerce.

• Manufacturing Resources Planning

Manufacturing resources planning (MRPII) is a formal, enterprise-wide system that links several planning functions (business, production, material, capacity), master scheduling, supply requisitioning, shop floor control, and performance measurement. Implementation began at DoD sites in 1997. Among the operational metrics tracked, the implementing sites report decreases in inventory turn rates, increased capacity resulting from reduced cycle time, and reduced parts shortages.



Examples of Other Information Technology Advancements

- **Portable Maintenance Aids and Interactive Electronic Technical Manuals**

Portable maintenance aids (PMAs) are multifunction PC-based aids that can provide maintenance management information system (MIS) functions, access technical data, link with other logistics support systems, and serve as an interactive electronic technical manual (IETM). The IETM is the interactive software that improves the maintainers' ability to diagnose and repair malfunctions. In combination, the PMA and IETM significantly improve maintenance operations. For example,

- the PMA will be able to connect to embedded data chips in the equipment being diagnosed to extract sensor information for troubleshooting;
- work orders, spare parts inventories, requisition forms, and maintenance histories can be accessed electronically through the PMA; and
- technical manuals and specifications for the equipment being repaired will be available electronically.

- **Telemaintenance**

Telemaintenance is the electronic transfer of data or information between a maintainer and another individual or the source to apply more expertise during a maintenance task. Benefits include a higher-quality repair done right the first time and an increase in maintainer proficiency levels as expertise is shared in real time.

- **Global Combat Support System**

The Global Combat Support System (GCSS) is a strategy that provides information interoperability across combat support functions and between combat support and command and control functions in support of the Joint Warfighter. GCSS builds on existing technology, products, procedures, and integration strategies with the intent of leveraging information superiority as a key battlefield enabler.

- **Job Performance Aids**

Education and training for maintainers are delivered on line or in a multimedia setting in which the instructor is not physically co-located with the students. Travel expenses are significantly reduced.

3 Materials

• Aircraft Appliqué

Appliqué is a system of material that uses a primer, an adhesive, and a polymeric film. The use of appliqué as a paint substitute for aircraft coatings may have several advantages:

- Sizable reductions in maintenance labor hours
- Ability to perform appliqué concurrent with other aircraft maintenance
- Reductions in painting requirements because of longer life appliqué
- Decrease in hazardous materials
- Improvements in aircraft readiness because of quicker turnaround time and increased durability of appliqué.

Testing of this material has proceeded from the laboratory to the field: testing of small coupon-size squares (up to 6"x 6") to recent field testing of larger rectangles (up to a 2' x 4') on several aircraft platforms for both the Navy and Air Force.

• Environmentally Friendly Solvents

Each of the military services uses a variety of solvents for cleaning and degreasing. Many of these need to be treated as hazardous materials because they are volatile and potentially toxic. This project will replace many of the solvents with formulations based on lactate. These lactate-based esters provide significant benefits, including

- non-toxic and non-ozone depleting,
- low volatility, and
- recyclable and completely biodegradable within 24 hours.

The FDA has approved using these substances. Initial testing for degreasing railroad boxcars at Crane Naval Weapons Station has proved successful. Approximately 5000 tons of lactate ester are available from New Technology Inc. (NTEC) for project use at little or no cost.

Examples of Other Material Advancements

- **Low-Observable Material Repair**

New coatings are being tested that will reduce the time it takes to remove and replace the composite-material panels in the B-2 Stealth Bomber from 1 ½ days to less than an hour. In addition, replacing the pressure-sensitive tape, which was necessary to eliminate radar reflections, with an iron-filled elastomer called MagRAM also improves the B-2 bomber's radar reflection and makes it less vulnerable to low-frequency radar.

- **Direct-to-Metal Primerless Topcoat**

Direct-to-metal (DTM) primerless topcoat is a material that eliminates the need for a primer coat of paint. DTM requires only one step, thereby reducing emissions of volatile organic compounds (VOCs) by 45 percent. This also will reduce weapon system downtime and material inventories, and could improve corrosion protection.

- **Lead-Free and Antimony-Free Solid Film Lubricants**

Used widely throughout DoD, solid film lubricants (SFL) are classified as hazardous materials because of their lead and antimony content. Using lead- and antimony-free substances will reduce VOCs and have other environmental and health benefits. Testing of these products is under way.

- **Composite Materials Repair**

Advanced composite materials are difficult to repair. Development of a materials-state-based knowledge tool would provide engineering support at the point of repair for processing and substituting composite materials. The main expected benefits are a decrease in repair time and an increase in operational readiness.

- **Embedded Capacitive Materials**

New single-layer capacitive materials have been developed and embedded in standard commercial circuit boards. This single layer will replace 85 to 90 percent of the individual discrete chip capacitors on the current board. Advantages of single-layer embedded capacitive materials include better noise suppression and lower life-cycle costs because of fewer individual solder joints that could fail.